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ONGOING IMPACT OF THE "ADVANCED DIPLOMA IN EDUCATION: MATHEMATICS"

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Abstract

The Action Research Project in Mathematics Education was undertaken to study the impact on teaching and learning, of strategies introduced in the Advanced Diploma Programme in Education: Mathematics (2003), offered by AKU-IED. This programme is a one-year field-based programme. The main aim of the programme is to develop exemplary teachers who are reflective practitioners. Teachers from sponsoring schools participate in the programme which is designed such that seminars are held at AKU-IED during summer and winter breaks and on Saturdays, when most schools are off. During term time tutors visit the participants in the school. The purposes of field visits include: provision of classroom support to participants in their efforts to implement their learning in the real classroom; identify areas where participants require further support; and to enable reflection.

Action research was carried out by the tutors and the programme participants where certain teaching strategies were identified, introduced and implemented in the classroom. The implementation process of these strategies was studied by the programme tutors. The purpose of the tutors' research, which is reported here, was to generate local evidence of impact and look for micro impacts which would help justify teaching these methods to teachers more generally.

Findings from the study showed that the teaching strategies introduced as part of the Advanced Diploma Programme led to a positive change in the teacher's classroom practice, in the mathematics that the students learnt in the classroom, and how they learnt it. However, the study also revealed that certain contextual and other factors mediated the potential of these strategies to impact the classroom. The findings reported here primarily discuss: the teacher's subject matter knowledge, their experience and ability to handle student responses and their critical (as opposed to an unquestioning) use of the strategies introduced.

Introduction

The Action Research Project in Mathematics Education was undertaken to study the impact on teaching and learning, of strategies introduced in the Advanced Diploma Programme in Education: Mathematics. In the class of 2003, there were fifteen teachers from schools in Karachi. These schools included institutions from the government sector, private schools and AKES schools. The instructional team comprised of four tutors.

The main aim of the programme is to develop exemplary teachers who are reflective practitioners. Teachers from sponsoring schools participate in the programme, which is designed such that seminars are held at AKU-IED during summer and winter breaks and on Saturdays when most schools are off. During term time tutors visit the participants in the school. The purpose of field visits include: provision of classroom support to participants in their efforts to implement their learning in the real classroom; identify areas where participants require further support; and to enable reflection. Hence, to support reflection and enable a questioning stance towards their practice participants were expected to engage in small-scale action research projects. The cyclical nature of the programme where AKU-IED based sessions were followed by periods of intensive work in the field lends itself to conducting action research.

As part of the programme, participants were introduced to new teaching approaches and strategies. These include the following:

- **The do-talk-record framework (Open University, UK).** According to this framework, students are encouraged to do the mathematics in pairs or small groups. Concrete and semi-concrete materials are provided to aid the work. Students are expected to record their mathtematics using words, pictures or symbols and discuss the rationale of their decisions.
- **Cooperative learning strategy (Johnson, Johnson, & Houlbec, 1993).** According to Johnson et al (ibid. pp. 6-12), there are five basic elements that should be incorporated in small group work to make it cooperative learning. These include a) individual accountability; b) face to face interactions; c) positive interdependence; d) group processing and e) social skills i.e. to use appropriate interpersonal skills in small group work.
- **Use of problem solving strategies (Polya, 1957).** These strategies enable a focus on the problem solving process by suggesting iterative cycles of plan-act-review.
- **Open-ended questions to promote mathematical thinking (Zevenbergen, 2001).** These are mathematical tasks and/or questions that do not have one correct answer.

Rather, a number of possible answers or solutions are possible, acceptable and encouraged.

Methodology

The action research reported here had two interwoven strands: in one, the course participants learned to research their classroom practice. Their focus was to examine the use of the selected strategies introduced in the course, in developing teaching on their own.In the second, the tutors were involved in researching classroom impact processes resulting from the teachers' research. The primary purpose for the tutors was to examine the ongoing impact of the teachers' implementation of new strategies in the classroom context. The aim being to generate local evidence of impact and look for micro impacts that would help justify teaching these methods to teachers more generally. By impact we mean the process of change that resulted as new teaching strategies were introduced in the classroom.

Action research was seen as an appropriate approach to study impact, to understand how and if in-service teacher education brings about a change in the classroom. This is because action research is about bringing around an improvement in a social situation through participation in cycles of planning, acting, observing and reflecting, thereby creating possibilities for change and transformation (Kemmis & Mctaggart, 2000). While research on change (e.g. Fullan, 2001) has shown that when new ideas and practices are introduced in schools and classrooms, they are interpreted and adapted by the teachers (and others) who put them into practice within the context of their own situation, existing beliefs and practices. Thus the movement from source inputs in teacher education programmes to student outcomes is an adaptive process and action research provides an appropriate methodological approach to study this process and its outcomes.

The fieldwork spanned the period of one year and involved in-depth interaction among the teachers and the tutors-researchers. Each tutor-researcher worked with a small group of teachers as research participants. This included observing classrooms at least once a month. Each observation was preceded by a pre-observation conference and followed by a post-observation conference. A purpose of this conference was to provide classroom support and to sustain reflection through identification and discussion of emerging issues and concerns. The classroom observations and conferences were recorded in the form of field notes. In some cases, classroom interactions were also recorded on tape recorders.

The tutor researchers also met regularly. A purpose of these meeting was to sustain the

process of ongoing analysis through a focused discussion of similarities and differences in findings and identifying emerging issues and questions. These meetings were recorded on audiotapes and later transcribed. Teachers and tutor researchers maintained reflective journals. These journals were mainly to promote a dialogue regarding the teaching and learning issues arising during the course. Data comes from over a 130 classroom observations and as many pre and post observation conferences with the teachers, and about 20 tutor researcher meetings.

Findings and discussion

The findings and discussions reported in this paper draw from work with teachers, Reshma, Tehmina, Abida and Samina (pseudonyms). These were mid-career female teachers, teaching mathematics to classes VI and VII. Each of the four tutors worked with one of these four teachers individually. These cases provide representative examples of issues and themes that emerged largely in all the classrooms.

Findings showed that as her area of inquiry, the teacher Reshma looked at the use of concrete materials in mathematics classroom. She identified this area because she usually used concrete material to teach mathematical concepts but was not sure if she was using them effectively. She now wanted to study the process of using concrete materials to see whether or not they were being used effectively so that learning was facilitated.

Similarly Tehmina had also identified her action research focus as the use of concrete materials, as students in class VII worked at mathematics tasks in small groups. Her reasoning, as evident from her reflective journal, was:

> In my 13 thirteen years, I have not used this approach to teaching which I am using now after my training at AKU-IED. while working on a simple activity of investigating area and perimeter in the sessions at AKU-IED, I learnt, that children do not learn just by being told or by making shapes on the blackboard. Children won't be able to learn until they do it themselves and until they do get a chance to touch it themselves (Tehmina's journal entry translated from Urdu).

The other two teachers, Abida and Samina, introduced "cooperative group works" such as small group work incorporating some elements of cooperative learning strategies. Abida said that she used group work to maximize students' learning. From the observations it appeared that Samina's purpose of introducing cooperative group work was to enable

each member of the group to share her ideas about the task and develop mathematical thinking in the process.

Findings show a positive impact on the classrooms observed with the new teaching methods. For example, there is evidence to show that students' shared their real life experiences in relation to mathematics, offered alternative solutions to the mathematics problems and solved questions with less dependency on the teachers, when the teachers tried out new methods of teaching. Similarly the change process studied showed a positive impact on the teachers' classroom practice resulting from the engagement in the examination of their implementation process during the advanced diploma project. Certain issues and challenges were also identified which moderated the potential of these strategies to impact students' learning.

These findings are discussed in further detail below.

Student outcomes

The study provided immense opportunity to see how the student learning outcomes were impacted. Here outcomes have a broader focus that includes academic achievement, students' participation, and development of social skills. A reason for including this broader focus is that the Advanced Diploma Programme gave a lot of emphasis in encouraging students to develop skills and attributes in order to enable them to work cooperatively with their classroom peers.As students worked at mathematics tasks in the classrooms where the teacher used involved concrete materials, there was evidence of positive impact on their learning process and outcomes. This was observed from the kinds of questions that students asked in the classroom, the discourse in the classroom which was broader, and richer, than the discourse in a classroom where the textbook is the only resource and teacher transmission is the only strategy used. The kind of mathematics tasks that the students were able to do were beyond the scope of the textbook and investigative in nature.

To exemplify the findings from classroom data, some episodes are shared. In one class, Reshma gave the students cutouts of different quadrilaterals and asked them to measure the interior angles of the different shapes such as squares, rectangles, parallelograms, trapezium, rhombus and other quadrilaterals. She planned that once the learners measured all the angles, she would ask them to add all the angles to explore the sum of angles of a quadrilateral. Following is an extract from one episode during Reshma's lesson, where 'L' represents the learner and 'T' represents the teacher).

Learners measured three angles, A1, A2, and A3.

1. L2: Stop, Stop. There is no need to measure the fourth angle (and he started adding the three angles).
2. L3: What are you doing?
3. L2: The sum of three angles is 250° therefore fourth angle is 360° - 250° = 110°.

The teacher visited the group.

4. T: Did you measure all the four angles?
5. L3: No miss, Ali said we need to measure only three angles and fourth one we can calculate.
6. T: Ali, why do you say that?
7. L2: Miss, in the previous class you asked us to cut different triangles, tear their vertices and paste them on a single point. It was 180° in types of triangles. I think the same would apply for the four sided figures.
8. T: Are you sure?
9. L2: If square and rectangle vertices are torn and brought together at a point it will make 360°. Like different triangles have 180° as sum of the interior angles, so four-sided figure will give 360°.
10. T: Good observation.

The above episode exemplifies the change in the classroom discourse. The change was in the nature of interactions. Students were now asking questions (2. L3), providing explanations of their thinking (lines 3. L2, 5. L3, 7. L2) and making linkages between the new topics being introduced and their previous learning (refer 7. L2 above).

Similarly, evidence of positive impact of cooperative group work was found in Abida's classroom. The episode discussed below is taken from a lesson on ratios taught by Abida.Abida began by presenting a problem which she had invented herself (See box below). She asked the students to solve the problem in their respective groups. She then engaged them in sharing their solutions with the class.

The teacher wrote on the following problem on the board.

Problem:
The cost of three copies is Rs. 15. What will be the cost of 5 copies?

The teacher then wrote the following questions on the board for students to discuss:

- Can you put ratio between two quantities such as number of copies and cost of copies?
- What would be the relationship between two ratios?
- How would you find the unknown cost?

The teacher moved around while the students solved the problem. After that she invited them to explain the process on the board.

S1: Increase in number of copies will increase the cost.
Ratio between number of copies = 3:5.
Ratio between cost of copies = 15: 25.
T: How did you get 25?
S: The cost of one copy is 5 therefore I multiplied 3 and 5 by 5. Both ratios are equal.

The teacher invited another group.

S2 (wrote on the board) No of copies: Cost of copies.
1:5
3: 15
5: 25
S2: I multiplied 5 by 5 because the cost of one copy is Rs. 5.
T: All of you got 25.
S (in chorus) Yes

The teacher then explained the textbook method and asked them to do the questions given in the textbook.

The above data excerpt shows that Abida encouraged the students to engage in dialogue with one another and with herself. She also encouraged and accepted students' ideas and sought elaboration of their responses. She recognized the students' potential and motivation

in the classroom when she encouraged their confidence by giving them an opportunity to express their ideas. In the post-observation conference, she said that before she began the textbook exercise, it was her intention to start with a problem situated in the students' daily life. She praised the students' participation in sharing their thinking about different ways of solving the question.:

> I had not expected the explanations they came up with. I was surprised when they solved the questions using the unitary method; I had not taught them this method previously (Abida's journal).

Abida maintained that her greatest achievement was the contribution of a student who participated in the class discussion for the first time. The student, S2, who offered the second solution, had never spoken in class previously and had failed in the examination for the past three years. She realized that when invited to contribute, the students had rich explanations to offer which demonstrated their active participation in the learning process.

Abida had previously observed the students' passive behavior in the mathematics classroom. She had assumed inferior capabilities of individuals' thinking because of her own learning experiences and limited goals for teaching mathematics. Her new beliefs about the students' learning with reasoning were not confirmed in the school reality until she observed the outcomes herself.

Samina was the other teacher to have introduced cooperative group work in her classroom. In a post-observation conference, Samina elaborated on the positive aspect of cooperative group work as follows:

> When I compared the students' existing learning about any topic with their previous learning, I found a clear difference. Now that they talked in small groups, they were learning with understanding, asking related questions to overcome their misconceptions. The students were now thinking deeply. For example, when I started the topic of circles in my class, after introducing the basic concepts about the parts of a circle, I started teaching them the method of solving word problems related to circles. These problems involved finding out the circumference when diameter and radius are given. When I wrote down the formula for finding the circumference of a circle many students asked me about "pi". Their questions were: Why is its value 3.142? Is it always constant? Does it

always remain the same? Even for bigger and smaller circles? These questions showed their desire to better understand the concept of pi. I then stopped explaining the textbook question on finding the circumference and decided to plan a lesson where students would be able to explore the relationship between the circumference and diameter of a circle, to find out the ratio between diameter and circumference (Quote from field notes of post-observation conference with Samina).

Teaching practice

Teaching practice in the classroom changed necessarily in the course of the programme. From analysis of classroom data it was evident that during their process of implementation, the teachers created situations in which the students worked in groups and were encouraged to bring out their informal and contextual experiences approaching questions through their own methods. All these methods centered on the students' active participation and involvement in their learning. As a result of these new experiences, the students demonstrated independence in their learning. For example, in the episode from Reshma's class that was shared above, there is evidence of a classroom discourse, which is richer in terms of the nature of students' interactions than what our earlier observations revealed.

Also apparent, was a positive change in the instructional sequence observed. For example, teachers traditionally begin to teach a mathematics concept by first defining it, and then explaining and exemplifying the definition. The textbooks are also usually based on this sequence (e.g. Shaikh, et al., 1998). Our initial observations of participants' classrooms also showed a similar sequence being followed generally. However, our later observations increasingly showed teachers first providing the students with a number of examples and non-examples of the concept.

Often providing opportunities for investigative work related to the concept and the concept definition was abstracted from those examples and investigations. For example, traditionally "kinds of quadrilaterals" are taught such that each quadrilateral is defined, its defining features listed followed by some practice work on identifying and constructing the quadrilaterals. However in Reshma's class, we observed that she asked students to explore quadrilaterals provided to them in the form of cardboard cutouts and identify the defining features of each. Similarly, Samina described in the quote shared earlier in this paper, how she changed her teaching plans for the topic of circles so that she could enable students to meaningfully learn the concept of "pi". Research (Skemp, 1986) has shown this new instructional sequence to be more effective in developing students'

conceptual understanding.

Emerging Issues and Questions

Certain issues and questions emerged in the course of the change being initiated in the classroom processes. For example, in some places, use of concrete material hindered students' ability to use the conventional notations and symbols for representing mathematics concepts. For example, Tehmina gave a handful of colourful buttons to small groups of students and asked them to make equal and equivalent sets with those buttons. Observations showed that when the class worked with colourful buttons, Mehvish, (a student), easily formed a variety of sets and correctly identified them as equivalent, equal and unequal sets. But in the final activity where Tehmina evaluated students' knowledge of equal and equivalent sets, Mehvish who had worked successfully with buttons, identifying, sets formed correctly as equal, or equivalent, identified the following two sets as equal

A= {b, o, y}

B= {boy}

Mathematically, the two sets above are not equal because set A has three members while set B has one member. The commas are meant to separate each member. However, it appears that Mehvish had not recognised the significance of commas in the formal notation. This could have been due to the fact that when making sets with concrete materials she did not need to put commas to separate the distinct members of the set. Hence, the very advantage in enabling students to move away from the formal symbolism of mathematics became an issue when students could not follow some of the conventions that are particular to symbolic mathematical language.

Similar issues also arose in Reshma's class. For example in one class, Reshma referred to the students' bag as a "universal set" and things present in it such as text books, registers, copies, pencils, pens, eraser, etc. representing different sets. When she asked the students to represent the universal set and other sets formed using formal mathematical notations,, a few students wrote "U = {bag} and set A = {pencil, eraser, pen}". However, this is mathematically not correct as 'a set containing all elements under consideration is called the universal set' therefore the "universal set" must contain all the things present in the bag including the bag itself for example U= {bag, pencil, pen, eraser, geometry box, pointer, textbook, register, copy}. It could be that the teacher was not secure in her knowledge of mathematics to be able to address emerging issues and so the learners also

faced difficulties in understanding the concept and were a bit confused.

Conclusion

To conclude, the findings from the study showed that the teaching strategies introduced as part of the Advanced Diploma Programme led to a positive change in the teachers' classroom practice, in the mathematics that the students learnt in the classroom and how they learnt it. However, the study also revealed that certain contextual and other factors mediated the potential of these strategies to impact the classroom. Primarily from the findings reported here, these factors include: teachers' subject matter knowledge, their experience and ability to handle student responses, their critical (as apposed to an unquestioning) use of the strategies introduced.

The study was looking at the ongoing impact studying the change process as it unfolded in the classroom. An implication of the action research was that the teachers' implementation of new strategies was not their blind acceptance of new ideas; on the contrary, it was a process of the teachers' questioning routine practice, analyzing new strategy and deciding appropriate actions in relation to adjusting change within their classroom realities and school circumstances. The teachers have moved from the passive role to the more active through participating in this process of research and reinforcement of their critical reflection. Consequently, the teachers' involvement in researching the implementation process had engaged them in an evolving and continuous process of self-reflection. This could be seen as an indicator of the teachers' maintaining their learning to routine life in schools.

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